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Scientific Intelligence Report

THE SOVIET SA-3 MISSILE SYSTEM

OSI-SR/TCS/65-10
8 July 1965

Directorate of Science and Technology

Office of Scientific Intelligence

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THE SOVIET SA-3 MISSILE SYSTEM

Project Officer

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CENTRAL INTELLIGENCE AGENCY

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REFERENCES

The source references supporting this paper are identified in a list published separately. Copies of the list are available to authorized personnel and may be obtained from the originating office through regular channels. Requests for the list of references should include the publication number and date of this report.

PREFACE

The Soviets have deployed a surface-to-air missile system (designated the SA-3 by the US Intelligence Community) at more than 100 sites throughout the Soviet Union. This report summarizes significant recent information on the SA-3 and presents a preliminary analysis of the system. The assessments herein agree with current National Intelligence Estimates. The cutoff date of the latest source material is 1 May 1965.

CONTENTS

FIGURES

THE SOVIET SA-3 MISSILE SYSTEM

PROBLEM

To make a current assessment of the characteristics and performance capability of the Soviet SA-3 surface-to-air missile system.

CONCLUSIONS

1. The Soviet SA-3 missile system probably is a short range, low- to medium-altitude antiaircraft defensive weapon system. Its range limitation is believed to be about 10 to 15 nautical miles at altitudes of from about 1,000 to 40,000 feet. While the system may have a capability below 1,000 feet, the evidence is insufficient to define the lower limit, which is, in any case, terrain dependent.

2. The SA-3 missile, designated Goa by the West, is about 19.2 feet long, with three sets of four fins. It is a two-stage missile and is mounted in pairs on a trainable launcher. The warhead is calculated to weigh about 200 pounds and is probably a fragmentation type.

3. The solid propellant booster vehicle has a thrust of about 26,500 pounds. The sustainer is probably solid-propelled with about a 4,400-pound thrust.

4. The radar systems associated with the SA-3 are FLAT FACE (the acquisition radar) and LOW BLOW (the missile-and-target tracking and guidance radar.) Target handling capability, accuracy, and guidance mode of the LOW BLOW cannot be estimated since its characteristics are not known.

5. The Goa missile is also used in the surface-to-air missile system designated SA-N-1 by the West. This system has been found on Soviet destroyers and is associated with a multiantenna radar (designated PEEL GROUP).

6. Although the SA-3 missile system has been deployed at over 100 sites in the USSR since 1961, deployment has been relatively slow and less extensive than low-altitude defense requirements would suggest. Probably the increased low-altitude capability of the SA-2 has influenced the SA-3 deployment program. In any case, the SA-3 is not expected to be deployed as extensively as the SA-2, the system which the SA-3 apparently was intended to complement.

SUMMARY

In December 1959, the USSR had under development a surface-to-air missile system at the Kapustin Yar Missile Test Range. This system, designated SA-3 by the Intelligence Community, uses the Goa missile and was first deployed in 1961. The SA-N-1 surface-to-air missile system, which has been observed aboard the Kotlin, Kynda, and Kashin classes of destroyers since 1961, also uses the Goa judging from a recent Soviet TV film presentation. Dual launchers are used for both systems, but in the SA-N-1 system, the launcher is mounted on a barbette housing the spare missiles.

Two radars have been identified in the SA-3 system. One, the well-known FLAT FACE, is used as the acquisition radar. The other, designated LOW BLOW, is the guidance radar and consists of at least four antennas on a single mount. LOW BLOW appears to have a highly complex scanning system similiar in many respects to the SA-2 guidance radar, FAN SONG. [redacted] 25X1D 25X1

Each SA-3 site consists of four launch positions, each with a dual launcher, the LOW BLOW guidance radar, the FLAT FACE acquisition radar, four vans, and associated missile transport vehicles. The launch positions are usually arranged in a trapezoidal configuration around the LOW BLOW radar.

The low altitude assessment of the SA-3 system is based on technical analysis of the missile's performance, the use of FLAT FACE as the acquisition radar, and the mounting of the LOW BLOW and FLAT FACE radars on 70-foot towers or lower mounds at the SA-3 sites in order to avoid radar masking by nearby terrain or trees.

DISCUSSION

BACKGROUND

As of December 1959 the USSR had a new surface-to-air missile (SAM) system under development at the Kapustin Yar Missile Test Range.[1] Subsequent information has revealed that this system differed in size, configuration, electronics, missile, and launch equipment from the previously developed SA-1 and SA-2 SAM systems. The two developmental SAM launch sites, A and B, consisted of four road-served launch positions arranged around a centrally located guidance control area. (See figure 1.)

Launch Site A had four launch revetments positioned around a large circular guidance revetment. Each launch revetment and its access road form a "T" with the launch revetment at one end of the "T" bar and the other half probably used to position the missile delivery vehicle prior to backing into the launch revetment. Site A was unoccupied and incomplete at that time.

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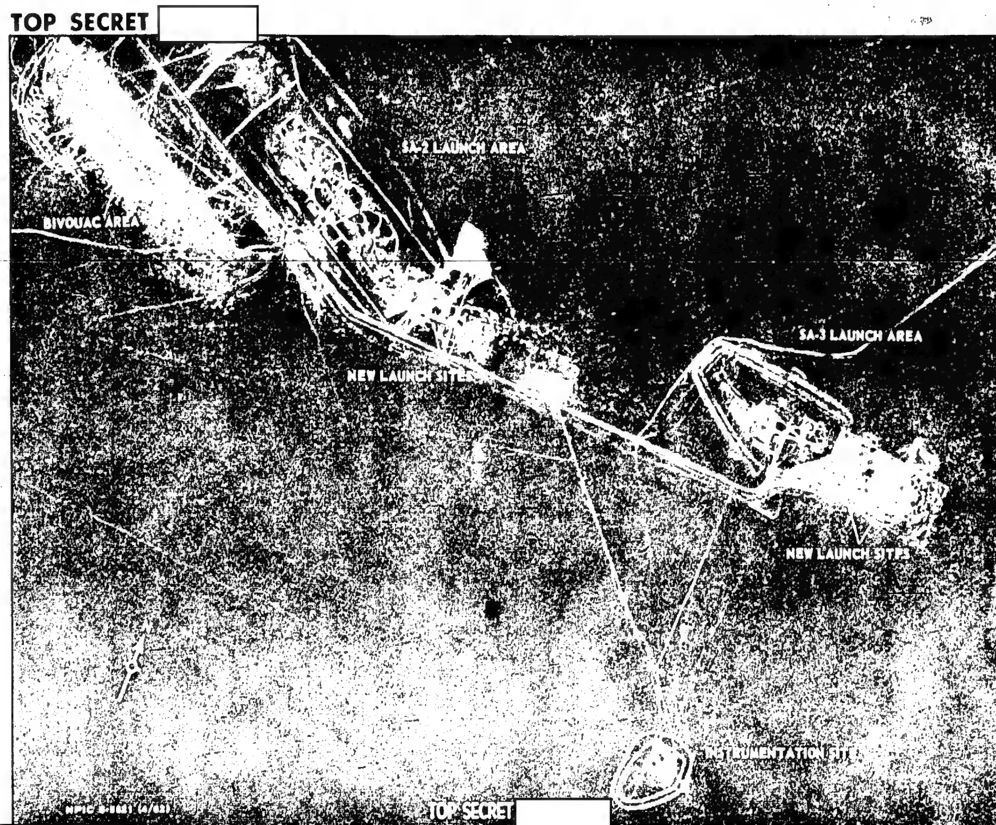

Figure 1 SA-3 LAUNCH AREA AT KAPUSTIN YAR/VLADIMIROKVA MISSILE TEST CENTER

Launch Site B had four nonrevetted launch pads positioned like "saw teeth" along a semicircular access road. All the pads were occupied by some equipment and one pad had what appeared to be two missile-like objects approximately 25 feet long. Two other pads had what appeared to be covered missile launchers. The fourth pad had an unidentified object parked on it. Located to the rear of the complex was a square, hipped-roof building which had a possible radar and three vans parked in front of it. The radar, not a FAN SONG, seemed to be offset on a pedestal with at least one large antenna and what appeared to be a large feed mechanism. At that time, Launch Site B was probably the research and development test site and apparently served for the development of the new missile system: Launch Site A was probably the prototype site. The SA-3 SAM system, which employs a modified version of the Launch Site A configuration, has been deployed to more than 100 sites throughout the USSR.

Even though almost all of the major SA-3 components have been identified, a complete analysis of the SA-3 system capability is not possible at this time. This

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RADARS

Two radars have been associated with the SA-3 system. One of these, nicknamed LOW BLOW, is a new radar that is believed to be the missile-tracking, target-tracking, and guidance radar. It probably utilizes the track-while-scan principle also used in the SA-1 and SA-2 systems. (See figures 2 and 3.) The other is the well-known FLAT FACE: it probably performs the acquisition function when used with an SA-3 site.

LOW BLOW Radar

LOW BLOW is the guidance radar associated with the SA-3 system and has been seen and photographed at several of the SA-3 sites in the USSR.[2-8] A radar photographed at Fili Airfield near Moscow was probably the LOW BLOW radar.[9] (See figure 4.) Unfortunately many details of the radar are not visible in the available photographs, but enough features are distinguishable to determine the general configuration of the various antennas. (See figure 5.)

The overall height of LOW BLOW appears to be 25 feet. The antenna array appears to consist of at least four radiating elements. Two FAN SONG-like "troughs" are mutually perpendicular and at a 45° angle to the horizontal in an inverted-V configuration. Of the two dish antennas, one is located above the apex of the "troughs," and the other is located in the angle of the inverted-V formed by the "troughs." The upper dish appears to be a paraboloid that has been trimmed into a square shape approximately 5 feet on a side. This dish is mounted with the sides of the square at an angle of 45° to the horizontal. This enables the dish to sit in the angle formed by the upper edges of the troughs. The feed arm apparently is erected from one of the upper edges of the dish.

The lower dish probably is a square

reflector measuring somewhat over 5 feet in each dimension and appears to be mounted with its edges parallel to the ground. A feed arm extends from the bottom of the dish supporting a feed device measuring about 2 by 2 by 2 feet.

The basic antenna structure apparently contains a cab to house various radio-frequency elements. The cab and the antennas are mounted on a column or tubular support structure. In addition, a horizontal crossarm is positioned on the column directly below the cab and the antennas. This crossarm appears to be carrying a tank-like object or cab on each end. The function and purpose of these are unknown.

The antenna assembly and the cab are capable of rotation through 360°; and the antenna's assembly is capable of movement in elevation from 0° to 90° (zenith).[10] Although the movement of the square dish cannot be determined, the upper dish may be capable of some limited independent movement, but the lower dish is fixed to the movement of the "trough" antennas. The horizontal bar probably is capable of independent movement in azimuth, and the attached tanks or cabs are apparently capable of motion above and below the level of the horizontal support arm. The whole antenna installation seems to be mounted on a platform which, in some views, resembles a wheeled trailer. (See figure 6.)

The function of the LOW BLOW antenna system is obviously to track targets and to control the associated missile. The "trough" antennas are adaptations of the track-while-scan antenna system used in the FAN SONG radar. Their orientation at 45° introduces some interesting possibilities as to ground reflection effects. The geometry of the situation shows that the image beam is removed to a plane at 90° to the plane of the incident beam and that interference patterns are confined to a small elevation-angle region. The upper limit of this region does not vary with the extent to which the direct beam penetrates the ground, as is the case with a vertical fan beam. There is a further consideration that if the target is in a clutter region, LOW BLOW would have an equal clutter power on each beam. Compared with FAN SONG, the increase of clutter in one beam would be well compensated by the decrease in the other.

If the two antennas of the Fili Airfield radar, which superficially resemble the FAN SONG but are smaller, were canted 45° to the right, they would then very nearly be identical to the LOW BLOW antennas at the SA-3 sites.[11] (See figure 7.) It is possible, but unlikely, that the 45° canted position of the LOW BLOW antenna "troughs" is the stowed or non-operating position and that the vertical-horizontal position is the operating position.

The two parabolic dishes, in any case, probably are concerned with the transmission of guidance data to the missiles and possibly with some form of early tracking. There have been no signals intercepted which can be definitely ascribed to the LOW BLOW radar. There are, currently, signals in S-, C-, and X-bands which have been intercepted under circumstances that lead to a possible LOW BLOW association, but position data are lacking.[12]

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[redacted]igure 2 LOW BLOW RADAR AT MYS SET NAVOLOK

[redacted] Figure 3 LOW BLOW RADAR, GRYZNAYA GUBA

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Figure 4 PROBABLE LOW BLOW RADAR, FILI AIRFIELD, MOSCOW

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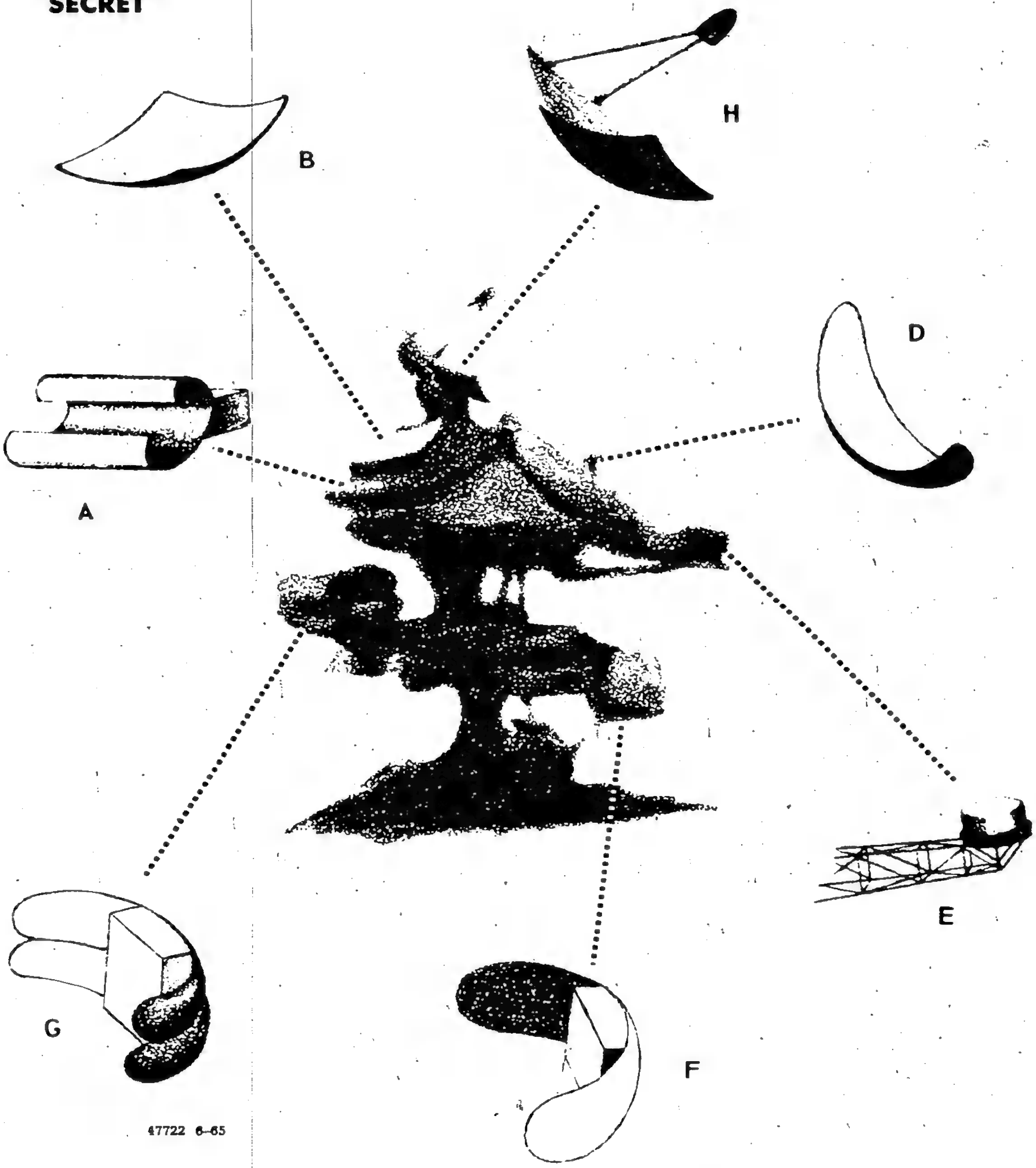

Figure 5 LOW BLOW RADAR SKETCH

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Figure 6 POSSIBLE LOW BLOW RADAR IN TRANSIT

Figure 7 POSSIBLE LOW BLOW RADAR
FILI AIRFIELD, MOSCOW

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FLAT FACE Radar

At several SA-3 sites, a FLAT FACE-type radar is identifiable.[2-7, 13] (See figure 8.) FLAT FACE is a mobile radar mounted on a ZIS-151 box-bodied vehicle. The antenna system consists of two elliptical paraboloids, each approximately 18 feet by 6 feet 7 inches high, mounted one above the other on a turntable on the front of the vehicle body. In the traveling position, the antenna arrays are folded down across the roof of the vehicle. The FLAT FACE radar is known to have been designed and used primarily for detecting low-flying aircraft targets, and its association with SA-3 sites strongly suggests that the SA-3 is a low- to medium-altitude antiaircraft missile defense system.[14-16] Thus far, the FLAT FACE radar has been observed operationally in two different variants. Which variant is used with the SA-3 system is not presently known.

The technical parameters of both FLAT FACE variants are:

	(1)	(2)
RF (mc/s):	815-845	880-900
PRF (pps):	240-290, 495-505	560-570, 598-602, 665-690
PW (microseconds):	1.4	2.4
Scan (seconds per revolution)	8.5	9.5
Polarization:	Horizontal	Horizontal

Because of the nature of radio wave propagation, pulsed radars which operate with their beams on or near the horizon have a severe problem with ground clutter obscuring the targets of interest. Moving target indicators (MTI) can reduce this clutter; but in so doing, they also reduce the sensitivity of the radar, as well as the range.

MISSILE AND LAUNCHER

Although two missile-like objects were observed at the SA-3 test site at Kapustin Yar, no details could be discerned. The SA-3 site at Mys Set Navolock in the Murmansk region and the 1964 November Parade in Moscow have provided configuration details of the missile.[2-6] (See figures 9, 10, and 11.)

Analysis of the Goa missile indicates that it is a two-stage missile utilizing a solid propellant in both stages. The missile is about 19.2 feet long as determined by photographs and mensuration, with three sets of four fins each. The forward fins are canard surfaces located about 3 feet from the nose; the wings, located near the booster-sustainer separation joint, provide lift and give roll stabilization through their pair of opposed ailerons. The length of the sustainer stage is about 13.6 feet, with a maximum diameter of 1.2 feet. The booster is 5.6 feet long, with a diameter of 1.7 feet. The use of a canard configuration possibly provides the missile with a more rapid response than the tail-controlled SA-2 missile. The choice of the canard control may possibly have been chosen because the use of a solid-propellant engine reduced the space

available for a tail control system.

The booster section of the missile incorporates a flip-back fin feature not previously observed on Soviet missiles. The booster fins are mounted with the leading edge toward the body and are hinged at the rear to allow for flip-back as the missile leaves the launcher. A locking device on the trailing edges of the booster fins secures them to the boost body in flight position. The booster engine, and possibly the sustainer engine, utilize an adjustable nozzle throat probably similar to that observed on the SA-2 booster. The adjustable nozzle on the SA-2 is used to keep propellant burning time and thrust within required limits regardless of the ambient air temperature. They probably have the same use on the Goa missile.

The warhead fuzing antenna(s) are possibly located in a raised rib on the forward section of the missile. Four additional antennas are possibly located on the wing tips. The latter are probably for the command guidance link. Because the warhead section of the missile does not appear to be large enough to accommodate a nuclear warhead, it is probably a high-explosive fragmentation type of about 200 pounds.

The missiles are mounted on a dual-rail launcher that is trainable in both azimuth and elevation. Although the evidence is not conclusive, the flame deflectors appear to be fixed. The launcher rail is about 13 feet long, and its apparent height above the ground is 6 feet. The launcher is believed to be road mobile since objects that appear to be bogies are visible in an area adjacent to the site.[3]

GOA NAVAL ASSOCIATION

The Soviet TV presented a film clip on 9 May 1965 pertaining to weapons development, which included an SA-N-1 surface-to-air missile installation on a Soviet destroyer. This film revealed that the Goa missile was used as the weapon in this system. The SA-N-1, which consists of a multiantenna radar, nicknamed PEEL GROUP, and a stabilized dual launcher, has been observed on the Kotlin, the Kynda, and the Kashin class destroyers since 1963. The dual launcher sits over a magazine which could hold approximately 20 Goa missiles.

MISSILE TRANSPORTER

A loaded missile transporter was photographed at the Moscow November 1964 parade, at Mys Set Navolock in March 1964, and earlier (in a covered state) at Gryznaya Guba and Odessa.[5-7] The missiles are mounted at a small angle (approximately 5°) with the missile nose protruding over the truck cab. The transporter is of the ZIL-157 family; it transports two missiles at a time. (See figure 12.) Vehicle chocks are probably used to align the transporter for off-loading the missiles onto the launchers.

GUIDANCE AND CONTROL VANS

In the central guidance and control revetment, three and possibly four vans (in addition to the LOW BLOW radar) are located, probably to house the guidance and control center and power source for the site. These vans are fairly

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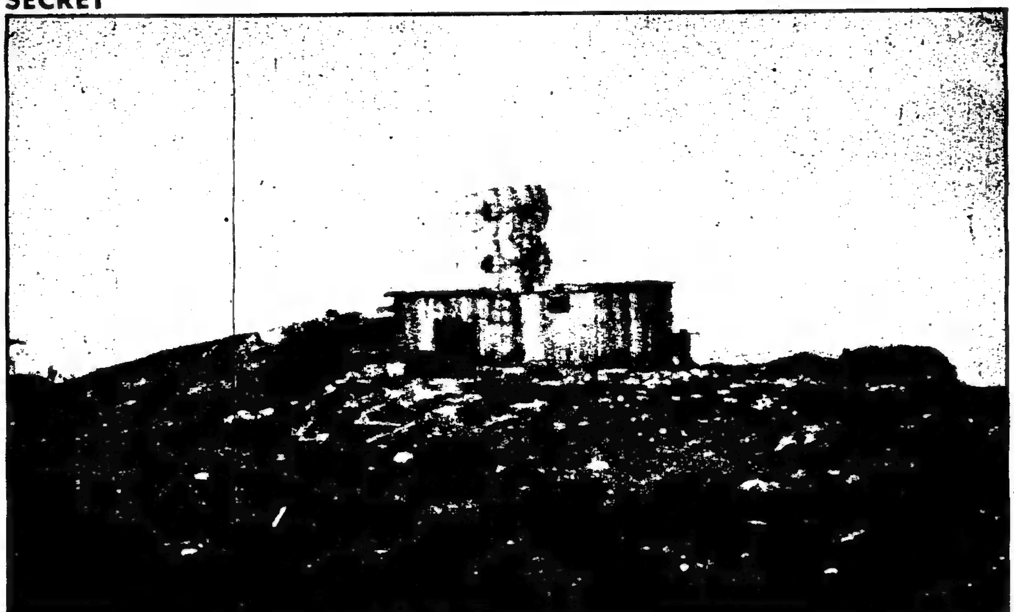

Figure 8 FLATFACE RADAR, MYS SET NAVOLOK

Figure 9 SA-3 SITE, MYS SET NAVOLOK, WITH GOA MISSILES ON LAUNCHERS

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Figure 10 GOA MISSILE

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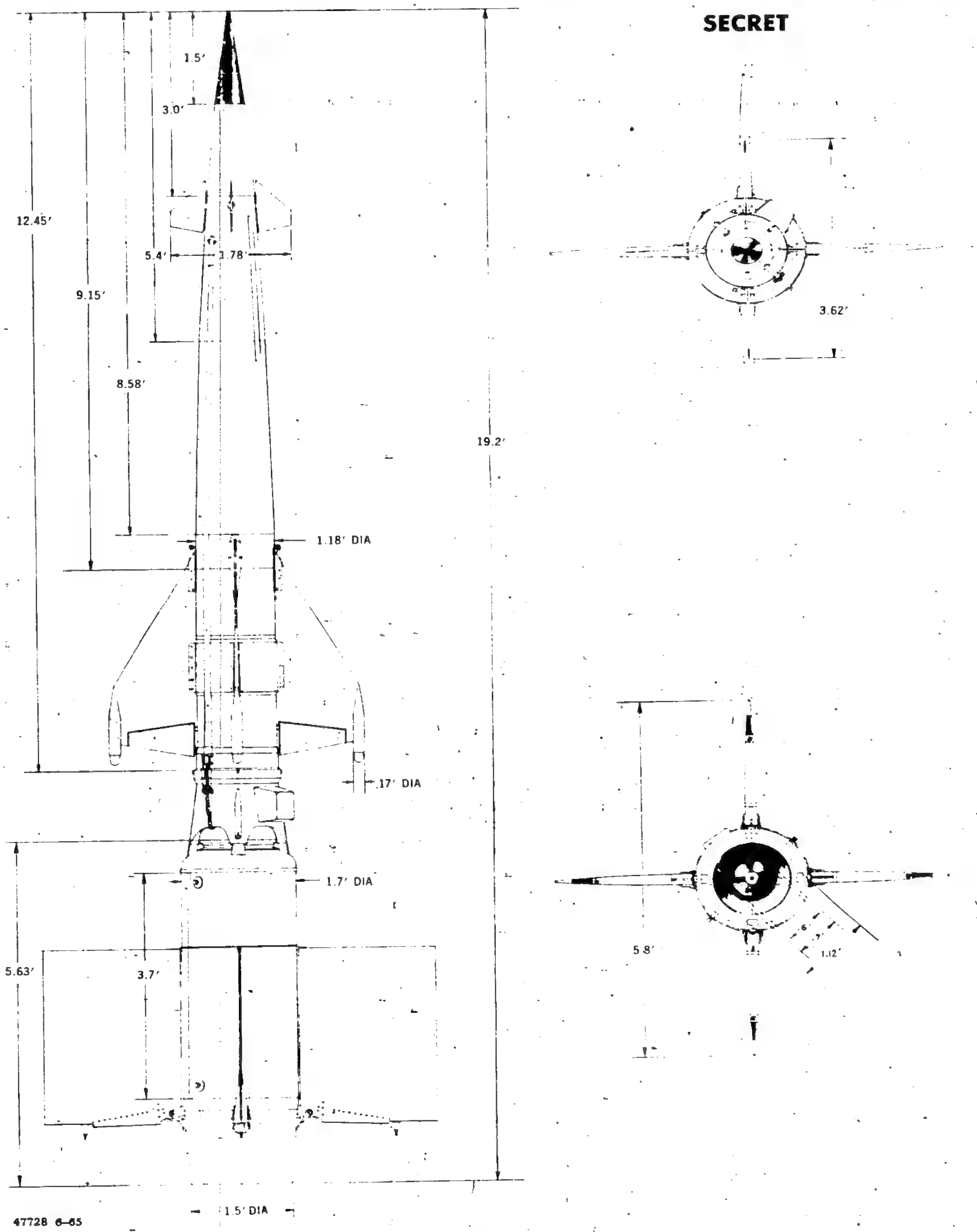

Figure 11 GOA MISSILE

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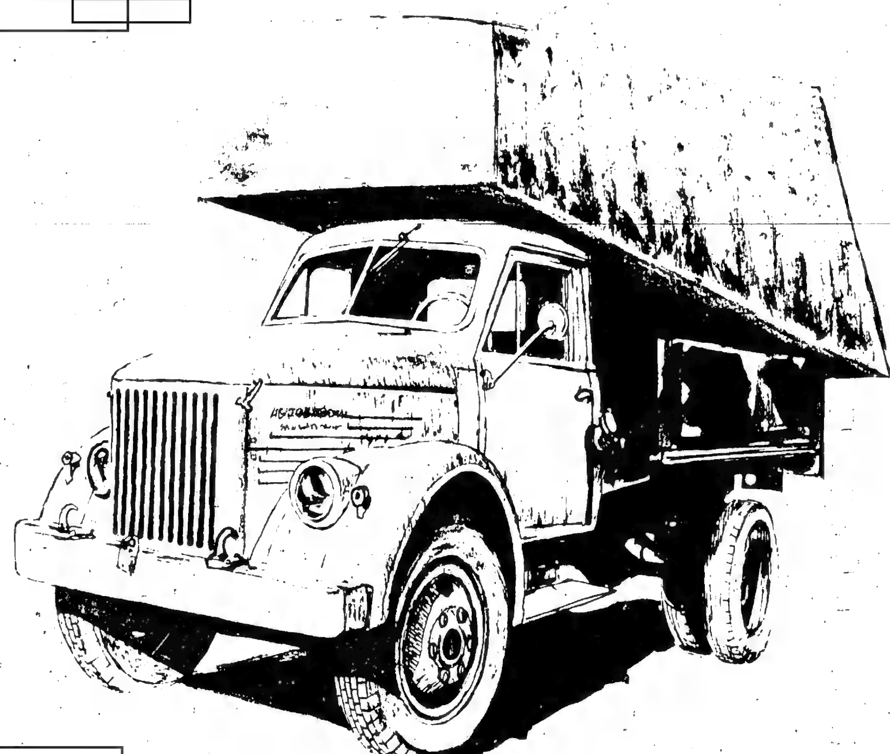

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Figure 12 SA-3 MISSILE TRANSPORTER

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large and appear to be towed vehicles. (See figure 5.) Because of their central location, their proximity to the LOW BLOW radar, and their cable connections to the launch area, they could function as the site weapons control center and house the computer and other electronic equipment.

COMMUNICATIONS

At two of the SA-3 sites studied, Mercury Grass communications antennas have been observed.[4 6] The Mercury Grass communication system, designated R401/M by the Soviets, is also used at all of the SA-2 sites; hence, its identification at some of the SA-3 sites indicates that it is probably used at all of the SA-3 sites.

The VHF multichannel communications (Mercury Grass) of 20 September 1963, servicing Soviet SAM elements in the Crimean area of the Southwestern Air Defense District, provided the identification of the Sevastopol SA-3 SAM site.[17]

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SITE CONFIGURATION

Thus far, three different basic site configurations with several variations have been identified for the SA-3 missile system. Two of the site configurations are basically modifications of Launch Site A observed at Kapustin Yar in 1959. (See figures 13, 14, and 15.) These sites, or launch complexes, consist of four launch pads arranged in a trapezoidal pattern or in a circular "buzz saw" pattern around a central guidance and control revetment.[13] Generally, each launch pad is revetted and occupied by a dual launcher. The central guidance and control revetment is occupied by a LOW BLOW radar and four vans. Another large revetted area, which is located at the approach to the trapezoidal launch zone, is used as the missile hold area and has been seen with the probable missile transporter vehicles in it. All launch positions are road served, and it is possible that the long road also serves as a missile hold area.

The other configuration observed is circular with the four launch positions spaced equally around the circular road. Inside the circle is the guidance and control equipment. A site of this type has been observed near Moscow and may serve as the training site for the Moscow area. The number of on-site support facilities is small in comparison with SA-2 sites and these facilities consist generally of at least one large building and several smaller buildings. Thus far, a specific support facility on the order of an SA-2 support facility has not been identified for the SA-3 system. It is possible that some of the SA-2 support facilities may serve the SA-3 sites as, for example, the support facility adjacent to the SA-2 site at Palanga.[13]

The Palanga SA-2 SAM Site, A03, is located immediately east of Palanga Airfield at 55°58'48" N/21°06'25" E. The Palanga SA-3 SAM Site, A03, is

located immediately north-northeast of Palanga Airfield at 55°59'30" N/ 21°05'50" E.[18] Their support facilities are grouped in three areas: Area A, which includes facilities associated with the SA-3 site; and Areas B and C, which include facilities associated with the SA-2 site. All three of the areas are connected by roads to each other and to the surrounding country. (See figure 16.)

Area A

This area, or complex, contains six buildings, an earthen mound probably used for acquisition radar, and the SA-3 site. The six buildings range in size from 20 by 20 to 100 by 30 feet. The largest of the buildings (100 by 30 feet) is probably a vehicle shed. It is located on the site access road and is connected to the road by a service apron. The exact function of the remaining five buildings, located about 200 feet south of the SA-3 site, cannot be determined at this time. There are no indications of security measures at either the SA-3 site or at any of the buildings.

Area B

This area, or complex, is located to the east of Palanga Airfield, immediately north-northeast of the SA-2 site, and 0.5 nautical mile south-southeast of the SA-3 site. It contains a secured section with three buildings serviced by a generally circular service road, six other buildings outside the security fence, and a POL storage area.

The nine buildings in the area range in size from 30 by 20 feet to 240 by 75 feet. Within the secured section of this area, the largest of the three buildings (240 by 75 feet) is adjacent to the generally circular road and connected to it by a service apron. The next largest building (70 by 60 feet) is located on the road and is probably a drive-through type. The smallest building [redacted] feet) is located adjacent to the road, but the exact manner in which it is served cannot be determined. An overhead probable pipeline connects a 60 by 30 foot building located outside the fences with an undetermined point inside the secured area. 25X

Area C

This area, or complex, is located immediately east of Palanga Airfield and contains the Palanga SA-2 site together with 14 associated buildings.

ELEVATED ELECTRONIC EQUIPMENT

Of the 100 or so deployed SA-3 sites, several have a serious radar masking problem caused by terrain features or high trees which would interfere with low altitude intercepts. Several of these sites were modified in 1963 and 1964 by the construction of a tower 55 to 70 feet tall in the guidance area.[19, 20] The towers appeared to have dark objects on top. (See figures 17 and 18.) At all of these sites, a second tower was constructed of the same apparent height and at a distance of from 500 to 800 feet to the rear of the first tower, and these too appeared to have an object on top. (See figure 19.)

Recent photography of the SA-3 site

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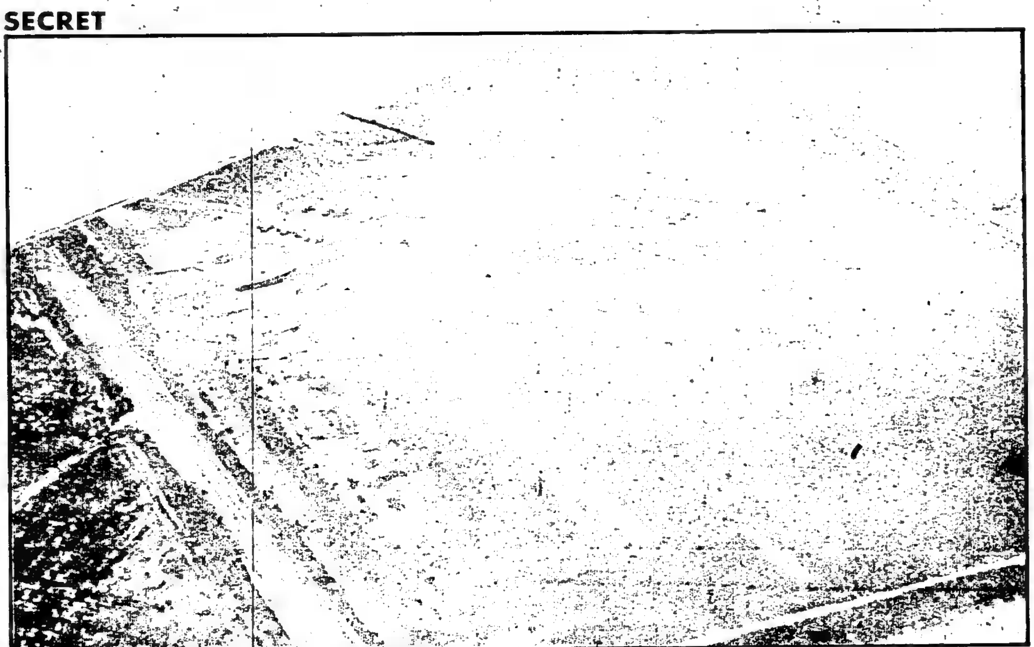

Figure 13 SA-3 SITE A-19-3, ODESSA, USSR

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Figure 14 SA-3 SITE, PALANGA, USSR

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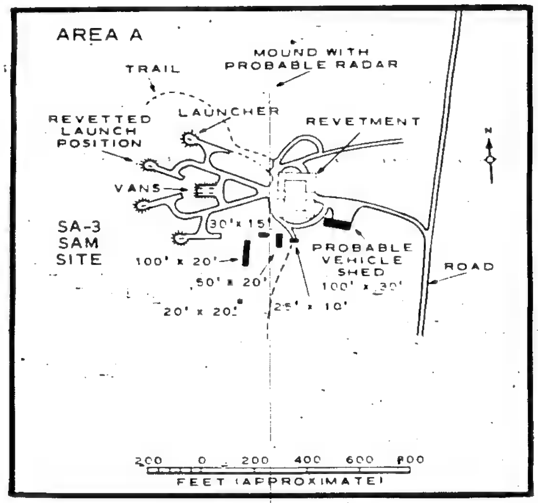
Figure 15 SA-3 SITE, PANRUPPE, USSR



PALANGA SA-3 SITE

Figure 16

SA-3/SA-3 SUPPORT FACILITY

PALANGA, USSR

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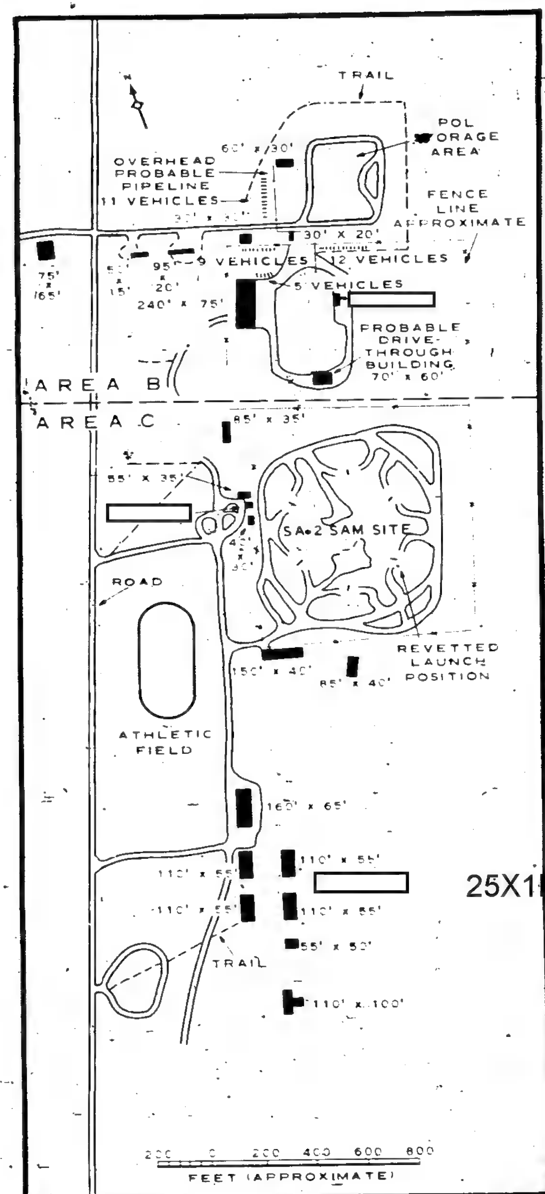

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PALANGA SA-2 SITE

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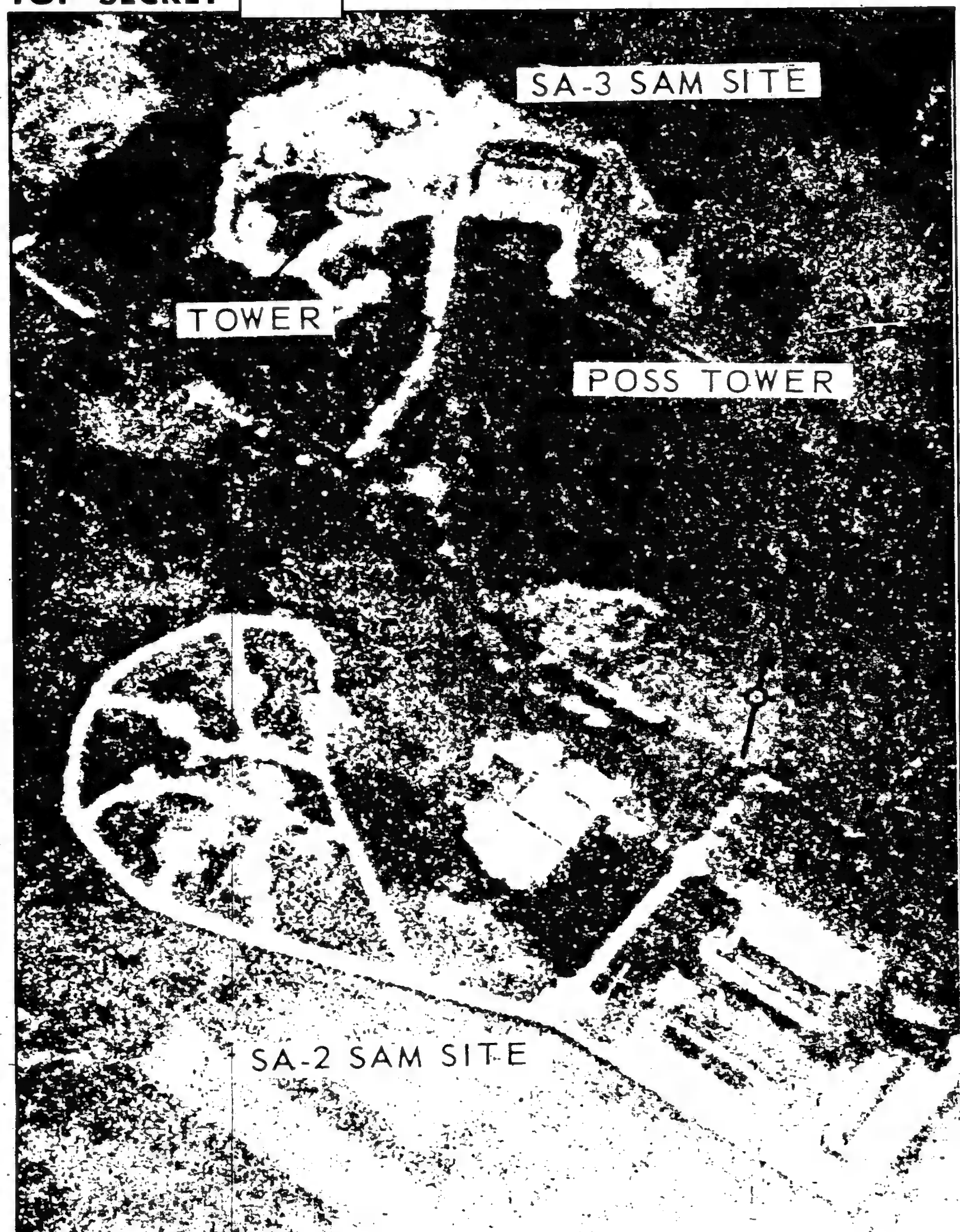

Figure 17 LENINGRAD SA-3 SAM SITE, B-29

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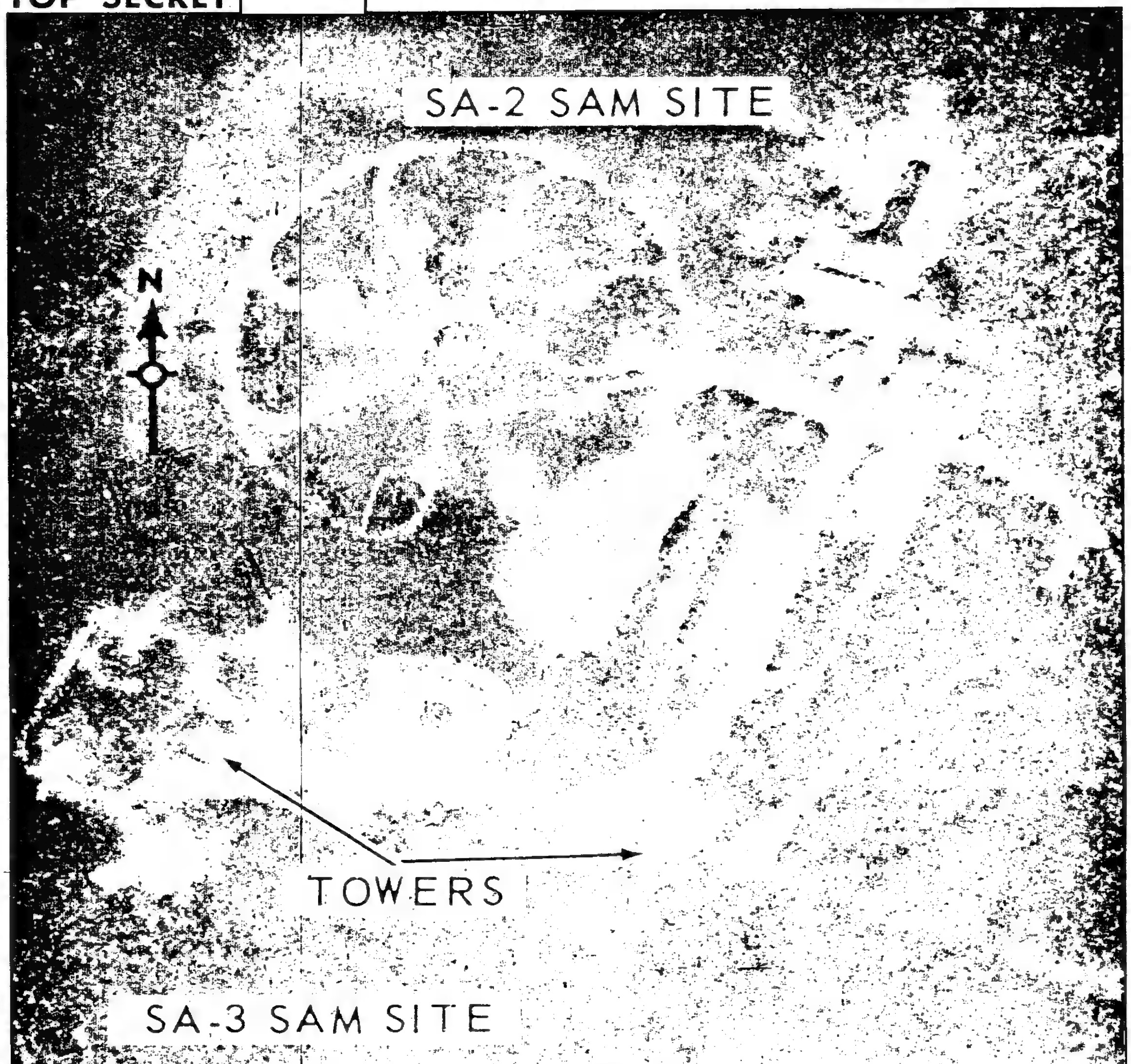

Figure 18 LENINGRAD SA-3 SAM SITE, C-31

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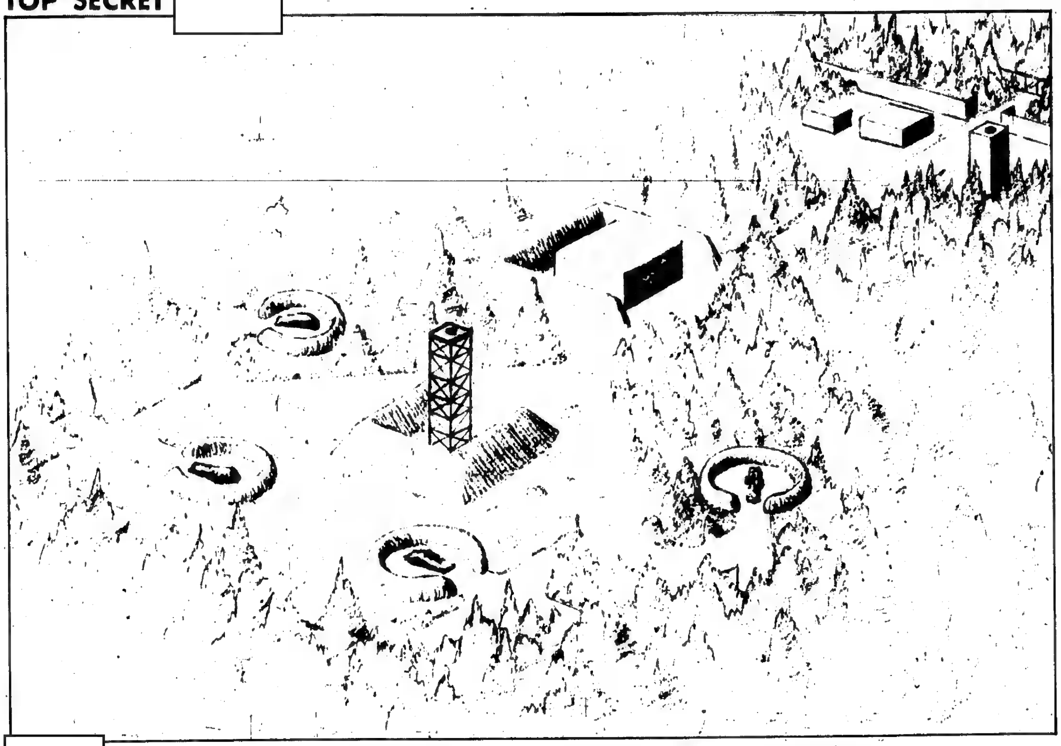

Figure 19 CONCEPT, SA-3 SAM SITE WITH TOWERS

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on Kildin Island at Leningrad reveals that the LOW BLOW guidance radar and the FLAT FACE acquisition radar are mounted on the two towers constructed at this site.[21] (See figures 20 and 21.) Large earthen mounds about 25 feet high with long ramps leading to the top have been constructed at six other SA-3 sites in the USSR.[22] [23] (See figure 22.) At one of these sites, Palanga A03-3, a probable FLAT FACE radar has been identified.[13] (See figure 14.)

In [redacted] a tower similar to those observed at Leningrad was seen at the SA-3 developmental complex at the Kapustin Yar Surface-to-Air Missile Test Range.[19] Subsequently [redacted] a probable radar was mounted on top of this tower.[24] A tentative negation date for this development is [redacted] This tower is in the guidance area of Launch Complex B, which has been assessed as the SA-3 research and development site at the range, indicating that the radar masking and/or ground clutter problem was serious enough to require additional developmental activity at the range.

MISSION

There are several indications that the SA-3 missile system was probably designed to engage aircraft targets at low to medium altitudes out to ranges of 10 to 15 nautical miles. The acquisition radar deployed with the SA-3 missile system is the FLAT FACE, an ultra-high frequency set that is the most effective Soviet acquisition set at low altitudes. Although the FLAT FACE has been employed in a variety of roles, it was designed primarily for the detection and tracking of low-flying aircraft. Reportedly, it is capable of tracking targets as low as 300 to 500 feet at 15 to 20 nautical mile ranges. That the Soviets intend to utilize the full low-altitude capability of the FLAT FACE is suggested by the emplacement of FLAT FACE radar at Palanga and elsewhere on an earthen mound. At the Mys Set Navolock and Gryznaya Guba sites, the FLAT FACE radars are on a hill overlooking the sea, and their low-altitude detection capability is thereby enhanced at those locations. In addition, at those sites where the LOW BLOW radars are on towers, the FLAT FACE is also tower mounted.

A further indication that the SA-3 was probably designed to have a very good low-altitude capability is the effort expended to overcome radar masking caused by trees and terrain features. Towers were constructed at the Kapustin Yar SAM Test Range and at several deployed sites, especially in the Leningrad area. Analysis of a few of these sites indicates that prior to the construction of towers, target aircraft below 1,000 feet were affected by the mask. After the construction of the towers, the radar mask essentially disappeared, and targets below 1,000 feet would be capable of being detected by the SA-3 radars. The emplacement of the LOW BLOW radar on the towers is another indication that the SA-3 was intended for low-altitude defense; if it were an acquisition problem alone, then only the FLAT FACE radar would have been raised. The modified sites strongly suggest that the USSR was concerned about coverage below 1,000 feet and that radar coverage by the guidance radars extends down to 200 or 300 feet at all sites and down to ground or to sea level at a few of the sites.

Assuming that the choice of the FLAT FACE as the SA-3 acquisition radar is by design rather than by accident, then the SA-3 has a low altitude (300 to 500 feet) role to perform. Similarly, the high-altitude performance of the FLAT FACE suggests an upper limit for the SA-3 system, in this case, medium altitude. The Goa missile, based on photography and reasonable assumptions regarding the control and propulsion system, probably has a level of performance adequate to intercept within the altitude capabilities of the FLAT FACE. The intercept capabilities of the SA-3 system will, in the final analysis, be directly dependent on the design of the LOW BLOW and the missile control system. There is presently insufficient evidence to assess the very low altitude capability (50 feet) of either the LOW BLOW or the FLAT FACE radars.

The deployment of the SA-3 system indicates that the SA-3 has an air defense role different from either the SA-1 or SA-2 systems, for in no case is the SA-3 the sole SAM system defending a target. Although a few of the SA-3's are collocated (within 1 nautical mile) with SA-1 or SA-2 sites, all SA-3 sites are well within the medium-to high-altitude area coverage of both the SA-1 and SA-2 sites.

The SA-3 missile system has been deployed in limited numbers in a few selected peripheral areas to cover aircraft penetration routes and at Leningrad and Moscow. The reason for the slow deployment rate is not known. It could have been caused by the increased low-altitude performance recently noted in the SA-2 system. In any case, the number of SA-3's to be deployed has been estimated to be not so extensive as the SA-2 system, probably on the order of 200 at the most.

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Figure 20. LOW BLOW TOWER, LENINGRAD

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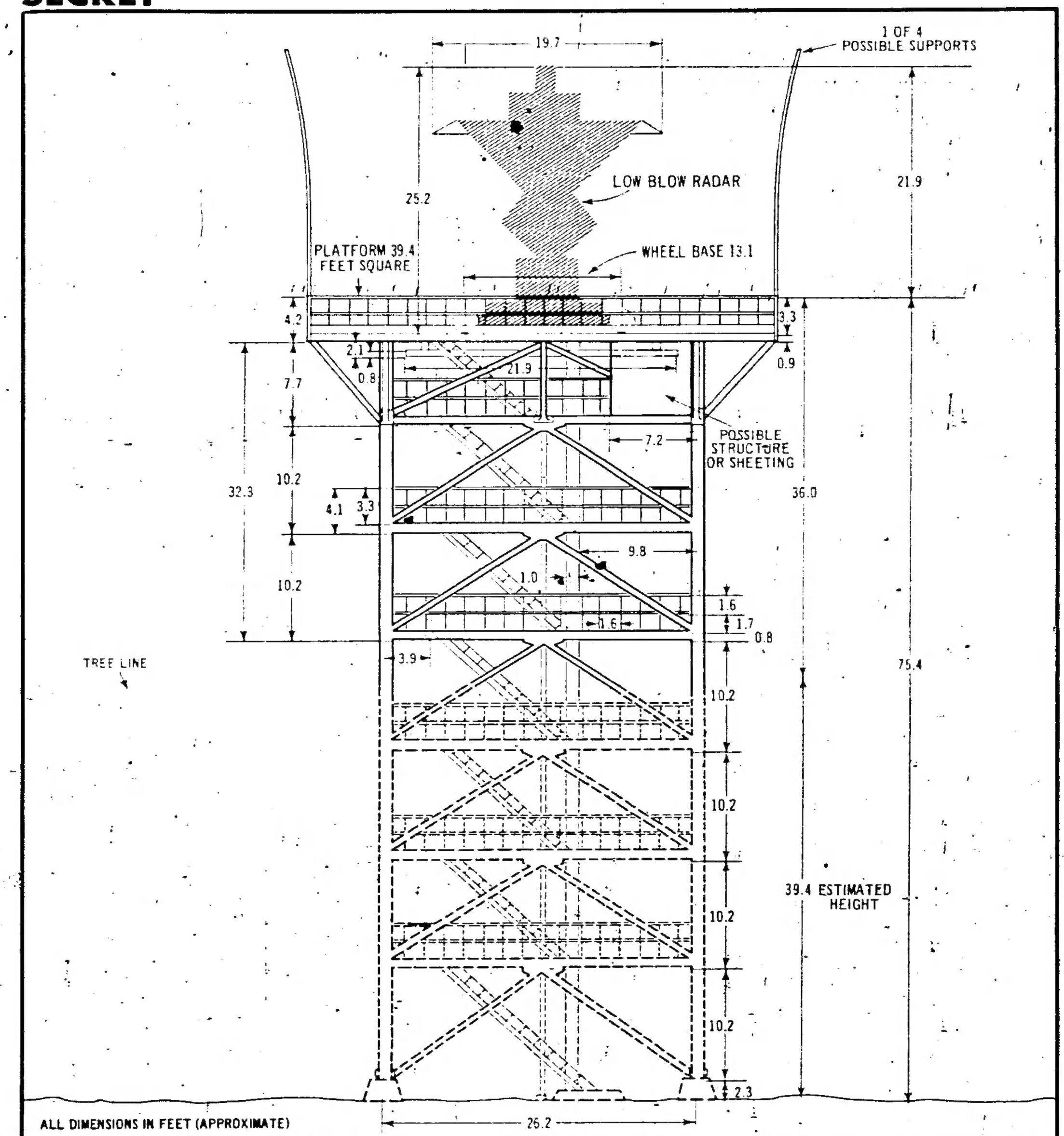

Figure 21 LOW BLOW TOWER, LENINGRAD

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Figure 22 PRUZHANY SA-3 SAM SITE, B-16A, WITH MOUND